TOWNSHIP OF WOODBRIDGE
NEW JERSEY

STABILIZED BASE
FOR
MUNICIPAL STREET CONSTRUCTION

"PROVIDES"

MORE STRENGTH
LOWER COST
CONSTRUCTION SPEED

CHARLES W. BEAGLE
TOWNSHIP ENGINEER
TOWNSHIP OF WOODBRIDGE
NOVEMBER, 1963

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PREFACE

The purpose of this report is to provide a written record of a municipal improvement problem and the unexpected results of the solution.

It is recognized that municipal funds do not provide for research. However the money spent for tests that guarantee the proper use of public funds is justified.

It is hoped that this report will create enough interest that some agency having facilities for research might initiate further study.

It is believed that the methods employed and the materials used as described in this report have provided a step forward in the design and construction of municipal streets. It has enabled Woodbridge to construct better streets, in less time, at lower cost.

Charles W. Beagle

Charles W. Beagle
Township Engineer

STABILIZED BASE
FOR
MUNICIPAL STREET CONSTRUCTION

In April 1963 the Township of Woodbridge initiated a street construction program which planned for the construction and surfacing of the township streets at the rate of one million dollars worth a year for a three year period.

Construction started as soon as plans and specifications were ready and bids received.

The subsoil prevalent throughout the Township, was the chief cause of a slower than normal rate of construction. The Woodbridge area has been a source of commercial clays for the past 160 years.

The Geologic identification of the soils are Glacial Moraine ranging from clays to silts, and silty sand, having a Highway Research Board Classification of A-4 to A-7. Very few areas having soil with an A-4 classification can be found.

When the subgrade was prepared and ready for spreading the 2 and 1/2 inch stone macadam base the appearance of the surface was good. In a matter of one or two hours, wet spots would appear. These wet spots would gradually become larger and the center of the spot become spongy. This was obviously caused by capillary action of the water in the soil and the effect of the sun.

These spots had to be removed and filled with Bank Run material or Quarry processed Stone.

During the operation of vibrating the screenings into the stone and rolling, additional soft spots would appear. These would have to be removed.

If it rained during the operation of preparing the base stone, work would stop for a period of days before it could be resumed.

After September it was foolhardy to attempt to do more than place the base stone and leave it until spring.

In September 1962 it was decided to try street construction with Stabilized Base.

The idea was concieved that if a layer of stabilized base could be laid that would provide a cohesive strength sufficient to support the wheel load without deflection then the clay would be confined and the same principles applied to rigid construction design could be applied to the stabilized base design.

It was believed that four inches of stabilized base and two inches of Bituminous Concrete Binder would provide sufficient strength to achieve the desired result.

However the sources of information available indicated that stabilized base should not be applied in lifts thicker than three inches.

The first street attempted with stabilized base was done with two lifts. Each lift being two inches compacted thickness. The first lift required quite a lot of patching due to the soft subbase breaking through the surface, before the second lift was applied. The second lift was applied very successfully and permitted the uninterrupted application of the binder and the surface courses.

At least a way had been found to overcome the problems of Woodbridge clays.

On the second street, the stabilized base was applied in one lift four inches thick. When soft spots were encountered, they were dug out two to three inches deeper and the stabilized base was allowed to fill the additional depth. On this street the excavation and the application of the stabilized base was completed in one day. (700 Lineal Feet)

The following day the binder and surface courses were applied.

Three additional streets were constructed with stabilized base during November 1962, and one street was completed on December 15th.

All of these streets withstood the winter of 1962-63 without any cracking and there was no apparent movement found.

On the basis of the success of the fall construction, three more streets were constructed in the same manner in the spring of 1963.

At this point it was believed that stabilized base could be used in one lift of five inches compacted thickness with a two inch compacted thickness of Type SM-1 surface for street construction on soils having low Bearing Ratios.

It is a known fact that in Bituminous Concrete surfaces the bottom quarter inch layer and the top quarter inch layer have a lower density than the inner layers of the surface.

It was reasoned that the same condition would apply to stabilized base applied in lifts. If this reasoning were correct then there would be a plane of material between the two lifts that would have a density lower than the material above or below the joint between the two lifts. A single lift would eliminate this plane of weakness.

It was reasoned that sufficient compaction could be obtained by proper selection of the rollers to be used. If the rollers could compact a smooth surface without wheel marks then the reaction force (the subgrade) would be great enough to provide compaction.

It was assumed that the seven inches of loose stabilized base required to provide a five inch compacted thickness would hold the temperature for a longer period of time and cause the rolling to be more effective.

Plans and specifications were prepared which permitted the contractors to bid five inches compacted thickness of stabilized base as an alternate to four inches of dry bound macadam base with two inches compacted thickness of Bituminous Concrete binder. The bids on the stabilized base were the lowest. The first contract for the construction of municipal streets in Woodbridge Township with stabilized base was awarded to the Halecrest Company of Edison, New Jersey.

The Jersey Testing Laboratories of Newark, New Jersey, were directed to sample the materials to be used by the Halecrest Company and to design the mix to provide a Marshall stability of 1,000 pounds at 140° Fahrenheit. They were also directed to conduct field California Bearing tests of "in place material" at locations and elevations on various streets, so that the character of the subgrade soil would be recorded.

WOODBRIDGE TOWNSHIP
ENGINEERING DEPARTMENT

FIELD CALIFORNIA BEARING RATIO TEST IN PLACE MATERIAL

Test No.	C.B.R. At 0.1"(%)	C.B.R. At 0.2"(%)	% Natural Moisture
1	20.5	17.3	19.7
2	2.9	3.7	14.9
3	7.3	7.7	14.9
4	3.9	4.6	16.5
5	8.8	8.5	16.4
6	2.9	2.7	21.9
7	17.0	16.0	12.5
8	11.3	11.0	17.1
9	12.3	11.0	18.3
10	11.5	14.3	14.7
11	15.5	19.6	11.5
12	19.3	20.2	21.0
13	67.0	51.5	15.3
14	7.3	7.1	25.0
15	7.0	7.3	15.6
16	4.0	4.1	19.3
17	26.1	22.0	13.4
18	20.0	17.7	10.2
19	5.5	5.0	24.6
20	2.5	2.7	16.5
21	2.2	2.1	21.3
22	5.7	5.5	17.1

The experience of the Halecrest Company during the fall of 1962 with stabilized base on Woodbridge soils had resulted in the use of a Jersey Box Spreader propelled by a Caterpillar Model 977H Loader, for spreading the material.

The first three hundred feet of street was laid with the New Jersey State Highway Mix designed for a Marshall Stability of 800 Lbs. at 140° Fahrenheit and which was being used on State Highway Route No. 18. The stabilized base was applied to the natural soil subgrade with two lifts of two and one-half inches compacted thickness.

The second three hundred feet of street was laid with the New Jersey State Highway Mix in one lift of five inches compacted thickness.

The New Jersey State Highway Mix was used so that cores could be taken at a later date for comparison purposes.

The second day, three hundred feet of street was laid with the Jersey Testing Laboratory Mix designed for a Marshall Stability of 1,000 Lbs. at 140° Fahrenheit. The mix was laid in two lifts of two and one-half inches compacted thickness.

The rest of the streets were laid with a single lift of five inches compacted thickness.

The purpose of specifying a mix having a Marshall Stability of 1,000 Lbs. at 140° Fahrenheit was to provide a safety factor against the possibility of not obtaining the desired density by the rolling of a five inch compacted depth.

It was believed that if the per cent voids could be obtained below ten per cent and a per cent compaction of about 94 could be obtained in the top half of the five inch lift and not less than 90 in the bottom half of the five inch lift, sufficient strength would be produced to prevent deflection under a 12,000 Lb. single axle load, and the low CBR soils would be confined, thus the desired stability would be obtained.

The Halecrest Company have two asphalt plants, a Mc Carter 5,000 Lb. plant and a Barber-Greene 4,000 Lb. plant. The two plants can produce 2200 to 2400 Tons of bituminous concrete per day.

The method of spreading the stabilized base made it possible to lay 23 tons of material in 27 seconds. Allowing for lost time the true rate potential of laying the stabilized base with the Jersey Box Spreader is 20 tons per minute or 1200 tons per hour. At this rate an entire weeks production of one plant could be laid in less than one day.

It was very evident that to use the Jersey Box Spreader to lay the stabilized base in one lift, a higher rate of production was desired.

An Emulsified Asphalt, Grade SS-1 was used to mix stabilized base for a part of one street, so that tests could be made to determine the characteristics of the emulsion mix.

Should the emulsion prove satisfactory for stabilized base for municipal streets, it would seem, that by the elimination of the screens and dryers, a properly graded gravel could be mixed in much less time, even stockpiled for several days before use. Such material would have to be left to cure before applying the surface. The use of such material could not be permitted after a date that would allow for the dissipation of the water carrier before frost.

It is conceivable that should the emulsion mix prove satisfactory, the possibility of doubling production exists during the summer months.

The rolling procedure was to make the initial roll as soon as sufficient base material was layed to permit rolling with a three wheel twelve ton roller. The compaction rolling was done with a twenty ton, three axle tandem roller.

Fine temperature cracks appeared on the surface during the compaction rolling but were not more than one half inch deep.

When the contractors first commence work on this type of street construction on low CBR Soils, areas in the subgrade suddenly become spongy and surface breaks occur. The contractors soon discover how to overcome this.

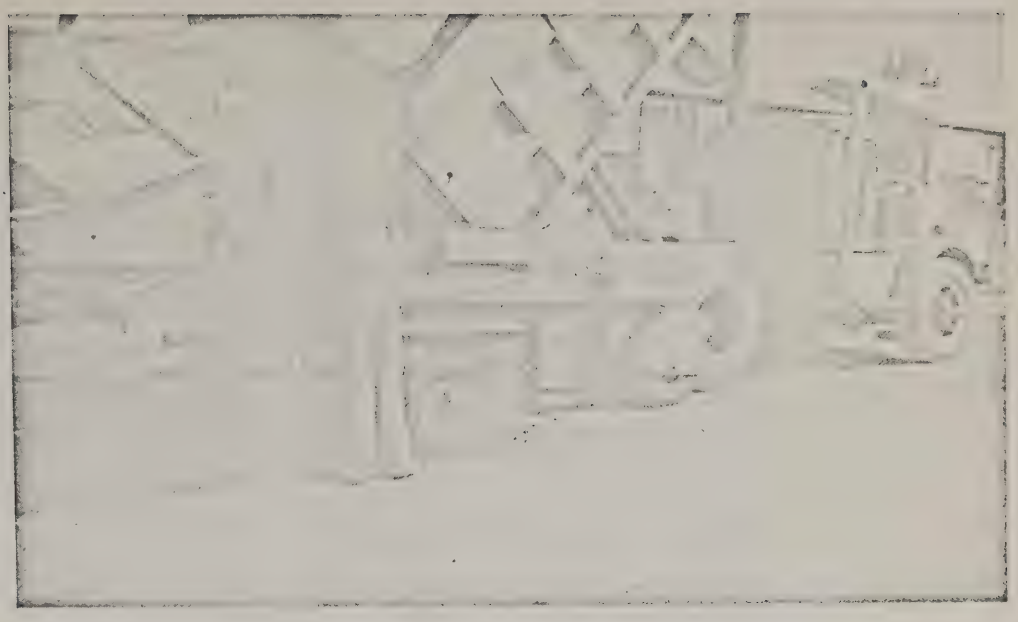
During the first two weeks, patching may be as much as 30 to 50 square yards per 1000 feet of street. As the crews become more experienced the required patching is only 10 to 20 square yards per 1000 feet of street. When the contractor coordinates his plant production with the field work, construction moves along at the rate of 500 to 600 lineal feet of street per day ready for surfacing. The days work includes the excavation.

With three contractors properly coordinated about 1500 lineal feet of street can be prepared for surfacing each working day.

Progress of Stabilized Base Construction

Excavation and preparation of the subgrade work commenced on a Monday morning at 8:00 A.M. Picture was taken at 10:00 A.M.

At 2:15 P.M. Stabilized Base was being applied.

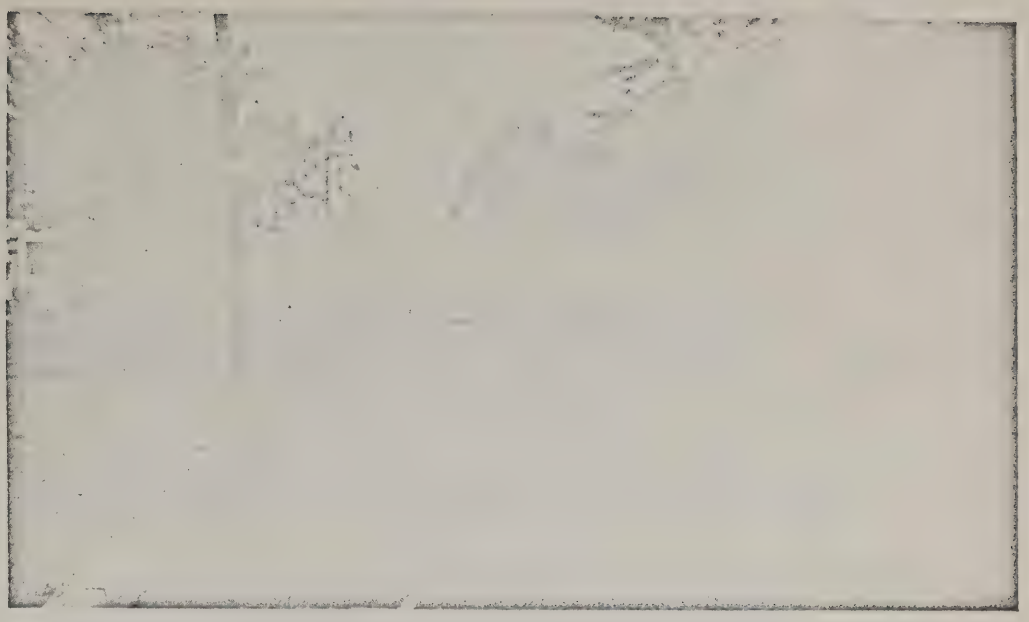


The Jersey Box spreader used for applying stabilized base.

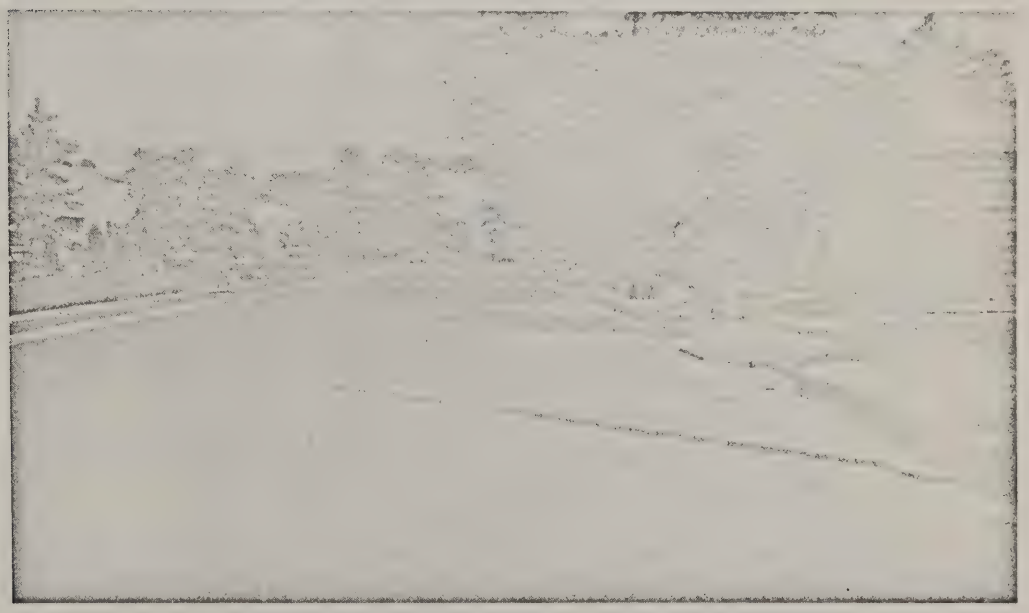
Initial rolling is done with a twelve ton three wheel roller.

Compaction Rolling with a twenty ton three axle tandem roller.

The Spreader, and the two Rollers applying stabilized base.



Tuesday morning at 11:00 A.M. Just twenty seven hours after excavation was started, 900 lineal feet of Stabilized base is completed and ready to be surfaced with Bituminous Concrete Type SM-1.



Completed pavement showing appearance with curb on the left, and without curb on the right prior to clean up.

The Jersey Testing Laboratories took four inch diameter core samples from designated areas of different applications and mixes. The instructions were to saw the samples in half so that the top 2 and 1/2 inch portions could be compared to the bottom two and 1/2 inch portions, and the 2 - 2 and 1/2 inch lifts could be compared to the 1 - 5 inch lift.

The results of the core samples indicated that contrary to all thinking the single five inch lift cores tested much better than the two, two and one-half inch lift cores.

As a check on this unexpected result, a pair of cores were sent to the New Jersey State Highway Testing Laboratory for test.

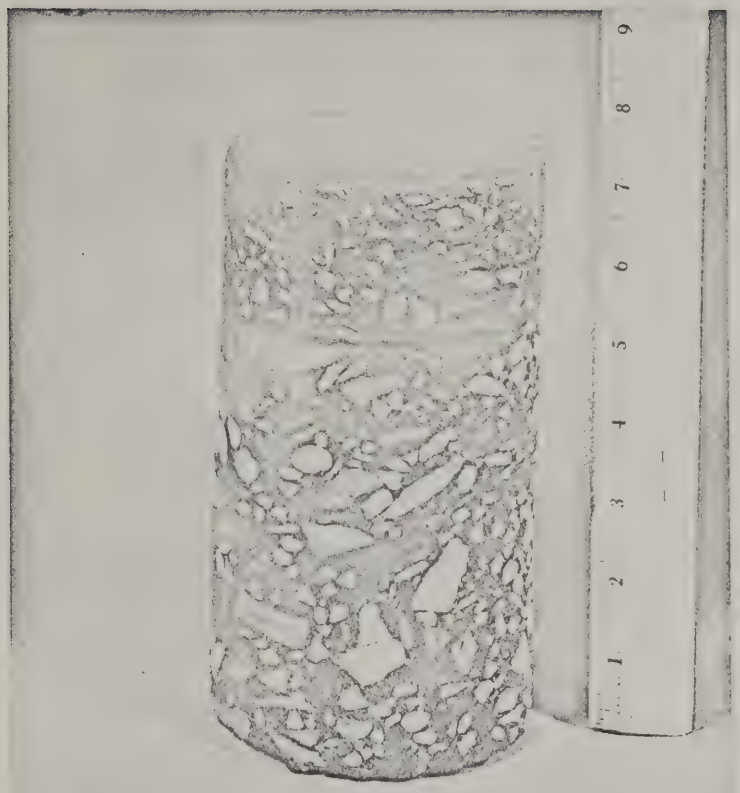
The results of the test showed that the cores from the single five inch lift was approximately one per cent better than the core from the two, two and one-half inch lifts in all respects.

The test results of the emulsion mix proved satisfactory for municipal work.

The test results prompted the recording of temperatures in the stabilized base after it was placed on the subgrade. It was the opinion that the temperature within the mix might be a reason for the results obtained.

Needle type asphalt thermometers were used. One thermometer was placed in the mix parallel to the surface and about 1 and 1/2 inches below the surface. The second thermometer was placed into the mix parallel to the subgrade and about 1 and 1/2 inches above the subgrade.

It was observed that the temperature of the mix near the surface was 290°. The temperature of the mix near the subgrade immediately dropped to 200°. In the following forty-five minutes the temperature near the surface dropped to 250°, the temperature near the subgrade dropped to 155°. The instant the roller passed over the spot there was no change in the temperature near the surface, but the temperature near the subgrade registered an immediate rise of 45° to 200°. It was noted that after the initial pass of the roller, the rate of temperature loss was slower than before rolling.



Picture of a Core taken from stabilized base construction showing the appearance of the gradation of the mix and the two inches of type SM surface.

The seven inch pavement is constructed on the natural subgrade.

WOODBRIDGE TOWNSHIP
ENGINEERING DEPARTMENT

MARSHALL STABILITY TESTS BY JERSEY TESTING LABORATORIES

MIX	NEW JERSEY STATE HIGHWAY DEPARTMENT				JERSEY TESTING LABORATORY				AMERICAN BITUMULS (EMULSION)
No. Of Lifts	2	1	2	1	2	1	2	1	1
Thicknees Of Lift	2 1/2"	5"	2 1/2"	5"	2 1/2"	5"	2 1/2"	5"	5"
Total Thickness	5"	5"	5"	5"	5"	5"	5"	5"	5"
Specific Gravity Top 2 1/2"	2.332	2.383	2.378	2.360	2.304	2.465	2.384	2.341	2.450
Specific Gravity Bottom 2 1/2"	2.346	2.337	2.319	2.298	2.334	2.459	2.373	2.337	2.467
Stability Top 2 1/2"	767	798			327	823		676	701
Stability Bottom 2 1/2"	806	953			480	968		728	508
% Void Top 2 1/2"	7.2	5.2	5.4	6.1	8.4	2.0	5.1	3.38	2.5
% Void Bottom 2 1/2"	6.6	5.4	7.7	8.6	7.1	2.1	5.6	3.55	1.9
% Compaction Top 2 1/2"	96.2	98.4	97.9	97.2	95.0	101.5	98.4	96.62	100.9
% Compaction Bottom 2 /2"	96.5	97.8	95.5	94.6	96.3	101.2	97.9	96.45	101.5

Form #LB-3

NEW JERSEY STATE HIGHWAY DEPARTMENT
Bureau of Testing and Materials

ANALYSES OF BITUMINOUS CONCRETE

Drilled Cores from the Road

Bituminous Stabilized Base Course (with Stone) Bottom

10-14-63

PAVEMENT MIXTURE Type Gravel (added) Top

Serial No. 718072

Job Woodbridge Twp. (Not State Work)

					Reported to
Laboratory Serial No.		718072			C. W. Beagle ✓
Date Laid					
Date Taken					
Date Received at Laboratory		9-18-63			
Sample Submitted		by C. Beagle			
Sample Taken from	Sta.				
Thickness (Inches)	Bottom				
	Intermediate				
	Top				
Location of Producer's Plant		Edison Asphalt Inc., Metuchen, New Jersey			
Inspector's Number		Core #15 - Two 2½" Lifts			

SCREENS & SIEVES USED	Top Portion ANALYSES	Bottom Portion	Required Min.	Required Max.
Passing 1 1/2" & retained on 1" %	100	100		
" 1 " " 1/2" %				
" 3/4" %	90	85		
" 1/2 " " 1/4" %				
" 3/8 " %	73	66		
" 1/4 " " # 10 %				
" # 4 %	55	52		
" # 10 " # xx %	46	43		
" # 20 " # 30 %				
" # 30 " # 40 %				
" # 40 " # xx %	30	27		
" # 50 " # 80 %				
" # 80 " # xxx %	10	9		
" # 200 " %	5	5		
Bitumen Content %	5.3	5.5		
Stone Content (Ret. on # 10) %				
Liquefier & Moisture %				

REMARKS:-

Marshall Stability - lbs.	581	543
Specific Gravity(Bulk)	2.29	2.32
Maximum Theoretical Density	2.56	2.57
Per Cent Voids	10.5	9.7

JCR/mhh

Supervising Engineer, Testing Laboratory

Form #LB-3

NEW JERSEY STATE HIGHWAY DEPARTMENT
Bureau of Testing and Materials

ANALYSES OF BITUMINOUS CONCRETE

Drilled Cores from the Road

Bituminous Stavilized Base Course

10-14-63

Type Gravel (with / Stone / added)

Serial No. 718073

Job Woodbridge Twp. (Not State Work)

Laboratory Serial No.			718073			
Date Laid						
Date Taken						
Date Received at Laboratory			9-18-63			
Submitted by C. Beagle						
Sample Taken from		Sta.				
Thickness (Inches)	Bottom					
	Intermediate					
	Top					
Location of Producer's Plant			Edison Asphalt Co., Metuchen, N.J.			
Inspector's Number			Core #17 - One 5" Lift			

Reported to

C. W. Beagle

SCREENS & SIEVES USED				Top Portion	Bottom Portion	Required Min.	Required Max.
Passing 1 1/2"	& retained on	1"	%	100	100		
" 1"	"	1/2"	%				
" 3/4"			%	90	86		
" 1/2"	"	1/4"	%				
" 3/8"			%	72	66		
" 1/4"	"	# 10	%				
" # 4			%	53	47		
" # 10	"	# 20	%	45	41		
" # 20	"	# 30	%				
" # 30	"	# 40	%				
" # 40	"	# 50	%	30	26		
" # 50	"	# 80	%				
" # 80	"	# 200	%	8	7		
" # 200	"		%	3	2		
Bitumen Content			%	4.4	4.5		
Stone Content (Ret. on # 10)			%				
Liquefier & Moisture			%				

REMARKS:-

Marshall Stability - lbs.	702	376
Specific Gravity (Bulk)	2.32	2.35
Maximum Theoretical Density	2.55	2.58
Per Cent Voids	9.0	8.9

JCR/mhh

Supervising Engineer, Testing Laboratory

When the immediate rise in the bottom temperature occurred it was thought that the thermometer was broken. However when the thermometers were interchanged with each other the same readings were registered.

After several sets of readings to substantiate the initial loss in the bottom of the mix, and the immediate rise of 45° - 50° on the passing of the roller, it was agreed that another set of readings should be taken to find the effect on the subgrade temperature.

This time a hole was dug adjacent to the edge of the pavement, and a third thermometer was pushed into the subgrade parallel to the surface and about 1 and 1/2 inches below the surface.

The other two thermometers were placed in the mix as before. Upon application of the mix the same temperature drop occurred in the bottom of the mix.

The subgrade temperature raised from 90° to 95° in ten minutes and then settled back to 90° in the following thirteen minutes.

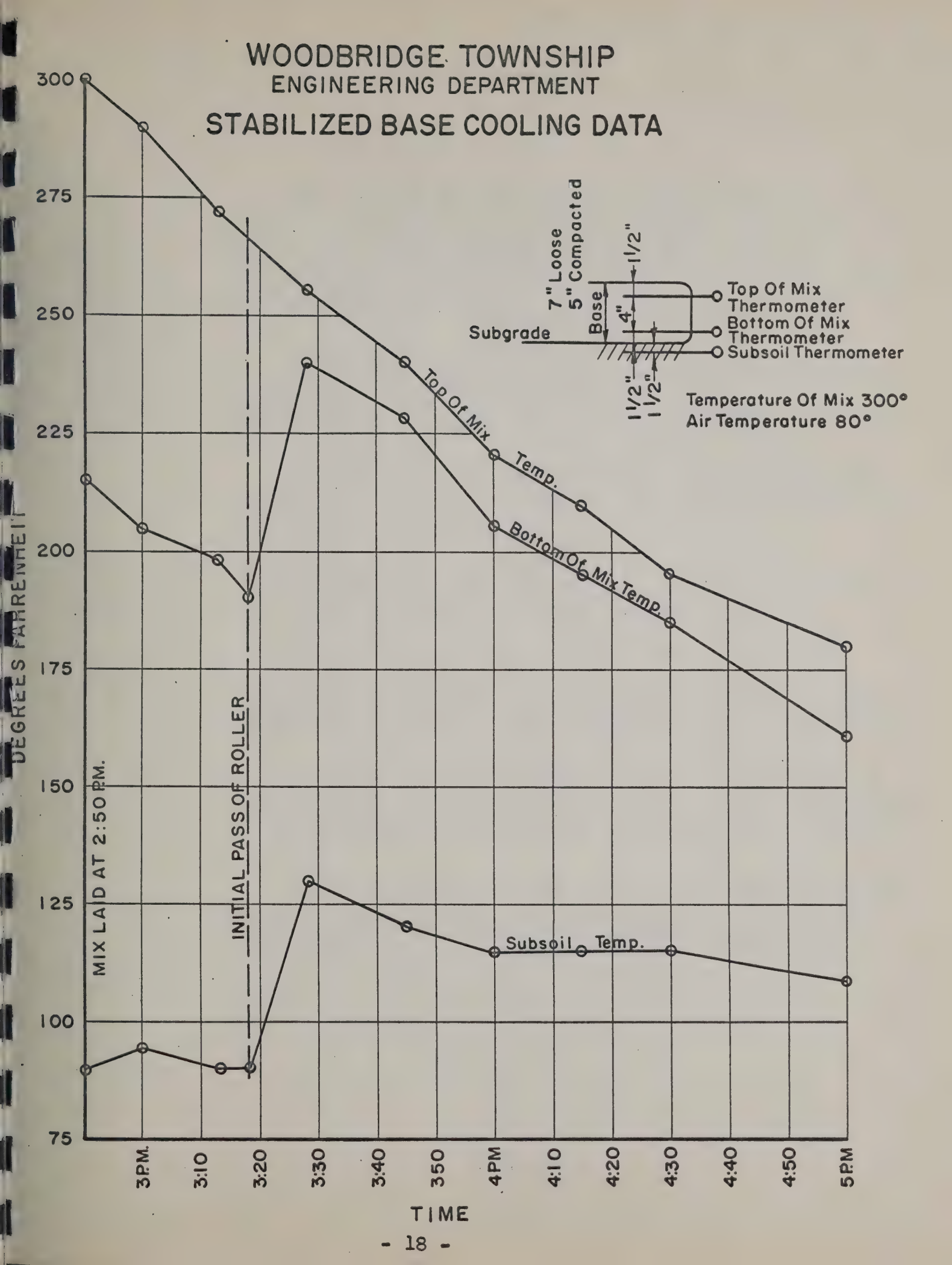
Thirty-eight minutes after application, the temperature at the top of the mix had dropped 45°, to 255°. The temperature at the bottom of the mix had dropped 25° to 190°, the subgrade temperature remained at 90°. Immediately upon contact of the roller there was no change in the temperature at the top of the mix. The temperature at the bottom of the mix immediately registered a rise of 50° to 240°. The subgrade temperature immediately registered a rise of 40° to 130°. Then all three thermometers recorded temperature loss at a gradual rate.

It would appear that the sudden temperature rise in the bottom portion of the mix at the instant of rolling provided some flow which assisted compaction.

The sudden rise of the subgrade temperature reduced considerably the transmission of heat from the mix to the subgrade.

These temperature characteristics could account for the better densities obtained.

WOODBRIDGE TOWNSHIP
ENGINEERING DEPARTMENT
STABILIZED BASE COOLING DATA



The strength of the pavement constructed with five inches of stabilized base and two inches of bituminous concrete surface Type SM, provides a strength twelve per cent better than the strength of the pavement previously specified for Woodbridge Township. The pavement previously constructed was dry bound macadam base, bituminous concrete binder and surface, totalling eight inches in thickness.

Stabilized base construction with a total thickness of seven inches costs five to ten per cent less than the previously specified pavement by actual bids received, plus the savings of the many tons of bank run gravel and quarry processed stone normally used to reinforce the base.

The speed of construction is the speed at which the stabilized base can be produced. One Jersey Box Spreader powered by a Caterpillar 977H Loader can handle up to 1,200 tons of stabilized base per hour.

Woodbridge is satisfied that they have found a way to overcome low CBR soils having a high per cent natural moisture, with stabilized base construction.

Better streets are provided in less time at lower cost.

It is not uncommon for a resident, leaving his home in the morning to ride to work on a broken, pitted, worn out street and to return in the evening over new stabilized base.

The Public Relations aspect of this type construction is astounding. Since the start of this program not a single phone call of complaint has been received about large stone, cut or punctured tires, blocked off roads, dust or bicycle accidents.

Unlike dry bound macadam construction which is halted for days due to a rain, once the stabilized base is rolled a rain has no effect. Work may proceed as soon as the weather clears, on the application of the surface.

A P P E N D I X

Mix Designs -

FORM 16

JERSEY TESTING LABORATORIES INC.

ENGINEERS, LABORATORY AND INSPECTION SERVICE
154-156 WRIGHT STREET At McCarter Highway NEWARK, N. J.

ATCO, N. J. OFFICE
ROUTE #30, WHITEHORSE PIKE

8-19-63

.....1st.....Report of Asphaltic Concrete Mix Design

Order No.....B-1196.....

Contract No.....

CLIENT: Township of Woodbridge, N. J.
PROJECT: Various Streets
SUBJECT: Asphaltic Concrete Mixture Design (Marshall Method)
REPORTED TO: Mr. C. W. Beagle, Township Engineer

We have visited the Edison Asphalt Plant and secured the following materials.

Material	Source
Asphalt Cement 85/100	Cities Service
Mineral Filler	Limestone Products
Bank Run	South River
3/4" Stone	Houdaille

Analysis of these materials were made and the following results were obtained.

Material	Filler	Sand	1/4 Bin	3/8 Bin	3/4 Bin
Total % Passing					
1½ Sieve	100	100	100	100	100
3/4 "	100	100	100	100	59.3
3/8 "	100	100	100	55.5	
4 "	100	100	42.4	.9	
10 "	100	93.7	2.1		
40 "	100	57.1			
80 "	100	13.1			
200 "	85	3.8			

These materials were blended in the following proportions to produce the proper mixture.

Stabilized Base

Material	% Total Mix	5000# Batch
Asphalt Cement	5.6%	280#
Mineral Filler	2.0%	100#
Sand Bin	39.7%	1985#
1/4 Bin	11.9%	595#
3/8 Bin	11.9%	595#
3/4 Bin	28.9%	1445#
Total	100.0%	5000#

FORM 16

JERSEY TESTING LABORATORIES INC.

ENGINEERS, LABORATORY AND INSPECTION SERVICE
154-156 WRIGHT STREET At McCarter Highway NEWARK, N. J.

8-3517

8-19-63

ATCO, N. J. OFFICE
ROUTE #30, WHITEHORSE PIKE

.....1st.....Report of Asphaltic Concrete Mix Design

Order No. D-1196

Contract No.

CLIENT: Township of Woodbridge, N. J.
PROJECT: Various Streets

Analysis of these mixtures produced the following results.

Material	Stabilized Base N.J.S.H.D. 1961	Spec.
Total % Passing		
1½ Sieve	100	100
3/4 "	87.4	65-100
3/8 "	63.8	50-90
4 "	49.6	35-75
10 "	41.6	25-60
40 "	26.1	12-30
80 "	7.6	6-20
200 "	3.4	3-8
Asphalt Cement	5.6	4-7

Marshall Data:

Stability @ 140°F	1100#
Flow @ .01"	12.1
% Void Total Mix	6.5
Unit Weight (pcf)	146.3
% Void filled by aggr.	64.5

Remarks: Providing that adjustments for variations of materials are made these mixtures should should satisfy the project requirements, pending approval of the Engineer.

Respectfully submitted,

JERSEY TESTING LABORATORIES INC.

Tech: D.L./t

BY: [signature]

Trial Mix Series:
Specific Gravity: Sand Bin 2.650 – ⅜ Bin 2.747
Specific Gravity: ¼ Bin 2.680 – ¾ Bin 2.906

Project: Various Streets
Location: Woodbridge Twp
Date: 8-19-63

Sp. Gr. AC: 1.025 Pen. Grade AC 85/100 Lab No. for AC used
Avg. Sp. Gr. Agg. Blend Lab No. for Agg. used

% AC-Spec No.	% AC-Spec No.	Spec. Hgt. IN.	Weight-Grams IN Air	Weight-Grams IN Water	Bulk Vol.-C.C.	Density Bulk	Density Max. Theor.	Volume-% Total AC	Volume-% Total Agg.	Volume-% Total Voids	Voids-% Agg	Voids-% Filled (Agg)	Voids-% Total Mix	Unit Wgt P.C.F.	Stability-Lbs Meas.	Stability-Lbs Adjust	Flow 1/100"
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
% AC By wgt of Agg	% AC By wgt of Mix				D-E	D/F	*	B×G / G AC	(100-B)×G / G Ag	100-I-J	100-J	I/L	100-(100G/H)	62.4×G		**	
	4.0		1095	626	469	2.338								145.9	675	804	6
	4.0		1126	642	484	2.325								145.1	610	665	7
	4.0		1033	586	447	2.310								144.1	650	812	6
	Avg					2.329	2.569	9.1	81.4	9.5	18.6	48.9	9.5	145.0		760	6.3
	4.5		1218	696	522	2.330								145.4	820	820	10
	4.5		1166	667	499	2.337								145.8	840	875	7
	4.5		1079	619	460	2.341								146.1	600	715	7
	Avg					2.336	2.555	10.3	81.3	8.4	18.7	55.1	8.6	145.1		803	8
	5.0		1148	658	490	2.340								146.0	890	920	10
	5.0		970	556	414	2.342								146.1	650	955	9
	5.0		1012	580	432	2.348								146.5	630	832	11
	Avg					2.343	2.530	11.4	81.2	7.4	18.8	60.6	7.4	146.2		902	10

* Max. Theor. Density
** See Correlation Table

$$\frac{100}{\frac{\%\,AC}{G\,AC} + \frac{\%\,Agg}{G\,Ag} + \frac{\%\,filler}{G\,filler}} = \text{Max. Theor Density}$$

Trial Mix Series: Project: Various Streets

Specific Gravity Sand Bin - 2.650 - 3/8 Bin 2.747 Location: Woodbridge Twp.

" " 1/4 Aggr Bin - 2.680 - 3/4 Bin 2.906 Date: 8-19-63

Sp. Gr. AC: 1.025 Pen. Grade AC 85/100 Lab No. for AC used

Avg. Sp. Gr. Agg. Blend 2.742 Lab No. for Agg. used

% AC-Spec No.	% AC-Spec No.	Spec. Rqt. in.	Weight of Specimen		Bulk Vol. - C.C.	Density		Volume - % Total			Voids - %			Unit Wgt P.C.F.	Stability-Lbs		Flow 1/100"
			In Air	In Water		Bulk	Max. Theor	AC	Agg.	Voids	Agg	Filled (Agg)	Total Mix		Meas.	Adjust	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
% AC By wgt of Agg	% AC By wgt of Mix				D-E	D/F	*	B x G / G AC	(100-B) x G / G Ag	100 - I - J	100 - J	I/L	100 - (100 G/H)	62.4 x G		**	
	5.5		1147	659	488	2.349								146.6	1000	1090	10
	5.5		1117	643	474	2.350								146.6	1100	1250	13
	5.5		1074	615	459	2.342								146.1	840	1100	13
	Avg					2.347	2.513	12.6	80.9	6.5	19.1	66.0	6.6	146.4		1113	12
	6.0		1255	719	536	2.341								146.1	970	900	12
	6.0		1032	590	442	2.338								145.9	685	905	12
	6.0		1358	775	583	2.331								145.5	1070	890	13
	Avg					2.337	2.491	13.7	80.1	6.2	19.9	68.8	6.2	145.8		898	12.3

* Max. Theor. Density

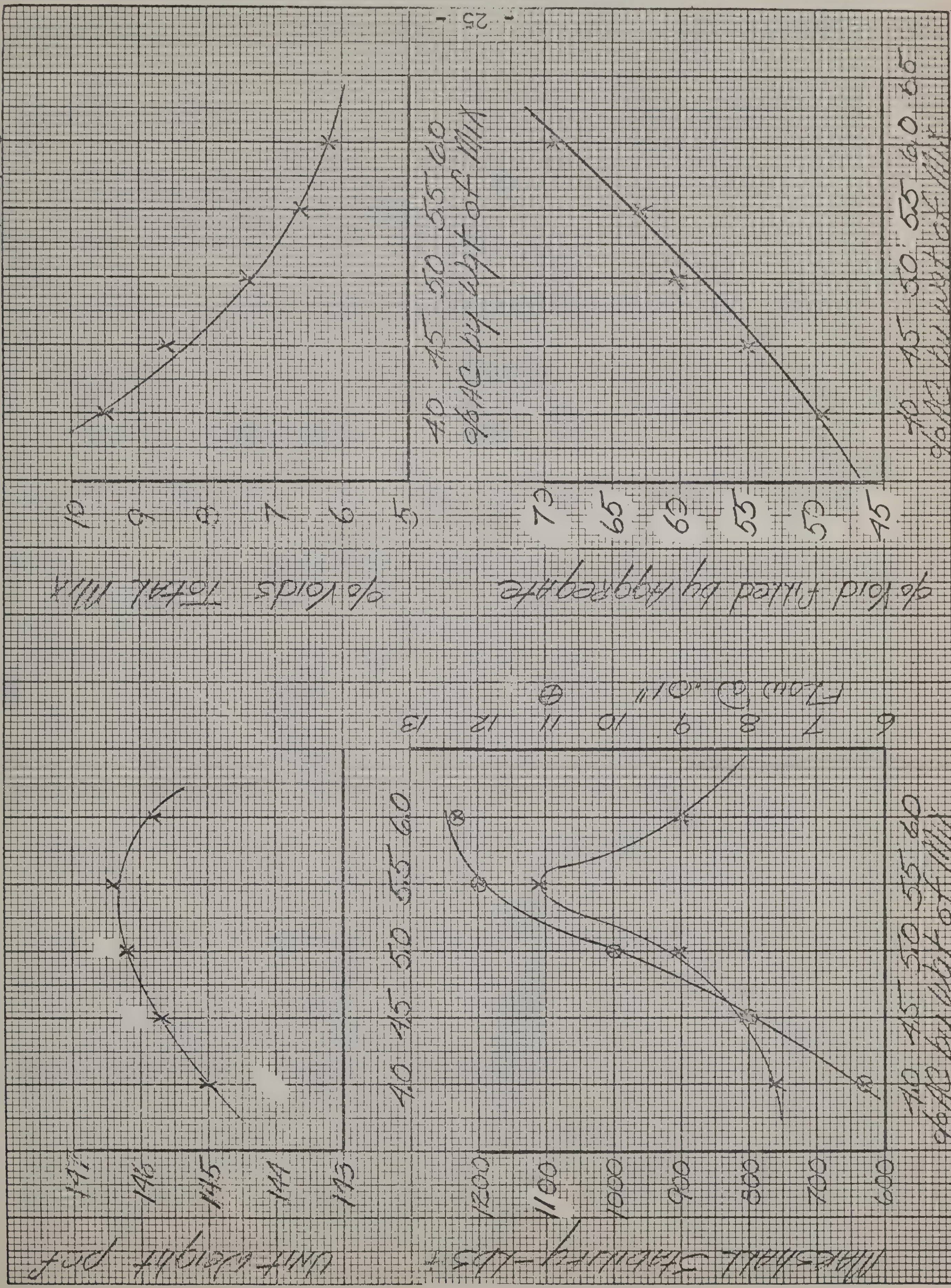
** See Correlation Table

$$\frac{100}{\frac{\%\ AC}{G\ AC} + \frac{\%\ Agg}{G\ Ag} + \frac{\%\ filler}{G\ filler}} = \text{Max. Theor Density}$$

JERSEY TESTING LABORATORIES INC.

Engineers, Laboratory and Inspection Service

154-156 WRIGHT ST. AT McCARTER HIGHWAY NEWARK 2, N. J.



FORM 16

JERSEY TESTING LABORATORIES INC.

ENGINEERS, LABORATORY AND INSPECTION SERVICE
154-156 WRIGHT STREET At McCarter Highway NEWARK, N. J.

S-5909

9-30-63

ATCO, N. J. OFFICE
ROUTE #30, WHITEHORSE PIKE

.....1st.....Report of Tests

Order No. B-1196

Contract No.....

CLIENT: Township of Woodbridge, N. J.
PROJECT: Various Streets, Woodbridge Township
SUBJECT: A Marshall Mixture Design
REPORTED TO: Mr. C.W. Beagle, Township Engr.

We have visited the Manzo Asphalt Plant and secured the following materials.

Material	Source
Asphalt Cement 85/100	Cities Service
Bank Run Gravel & Sand	Manzo

Analysis of these materials were made and the following results were obtained.

Material	Bank Run
Total % Passing	
1½ Sieve	100
3/4 "	90.2
3/8 "	67.6
4 "	54.7
10 "	44.3
40 "	26.0
80 "	9.8
200 "	6.2

These materials were blended in the following proportions to produce the proper mixture.

	Stabilized Base	
Material	% Total Mix	8000# Batch
Asphalt Cement	4.8%	384#
Bank Run Sand	42.8%	3424#
Bank Run 1/4 Gravel	17.1%	1368#
Bank Run 3/8 Gravel	15.3%	1224#
Bank Run 3/4 Gravel	20.0%	1600#
Totals	100.0%	8000#

FORM 16

JERSEY TESTING LABORATORIES INC.

ENGINEERS, LABORATORY AND INSPECTION SERVICE
154-156 WRIGHT STREET At McCarter Highway NEWARK, N. J.

S-5909

9-30-63

ATCO, N. J. OFFICE
ROUTE #30, WHITEHORSE PIKE

.....1st.....Report of Tests

Order No. B-1196

Contract No.....

CLIENT: Township of Woodbridge, N. J.
PROJECT: Various Streets, Woodbridge Township

Analysis of these mixtures produced the following results.

Material		N.J.S.H.D. 1961 Stabilized Base Spec.
Total % Passing		
1½ Sieve	100	100
3/4 "	90.2	65-100
3/8 "	67.6	50-90
4 "	54.2	35-75
10 "	44.3	25-60
40 "	26.0	12-30
80 "	9.8	6-20
200 "	6.2	3-8
Asphalt Cement	4.8	4-7
Marshall Data:		
Stability lbs.	1050#	
Flow @ .01"	7.2	
% Voids total mix	8.3	
Unit Weight	138.7 pcf	
% void filled by aggregate	56.5	

Remarks: Providing that adjustments for variations of materials are made, this mixture should satisfy the project requirements pending approval of the Engineer.

Respectfully submitted,

JERSEY TESTING LABORATORIES INC.

Tech: D.L./t

BY: E. R. Winegeter

Trial Mix Series:

Project: Various Streets
Location: Woodbridge Twp.
Date: 9-28-63

Sp. Gr. AC: 1.027 Pen. Grade AC 85/100 Lab No. for AC used

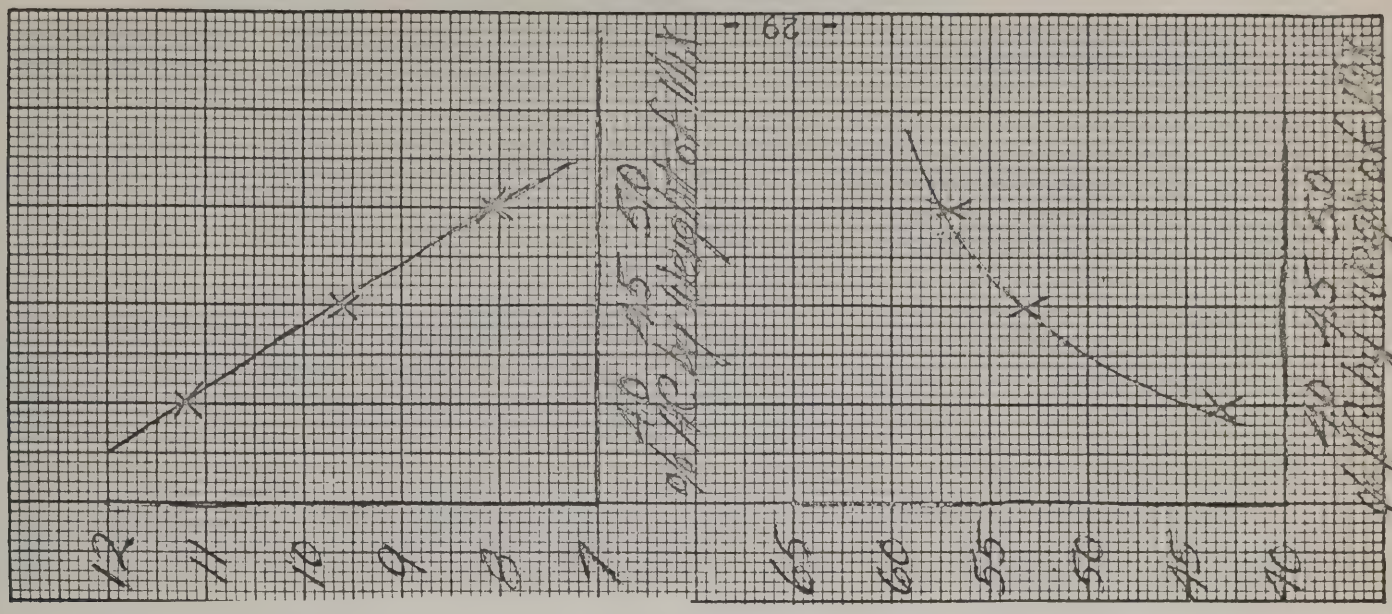
Avg. Sp. Gr. Agg. Blend 2.609 Lab No. for Agg. used

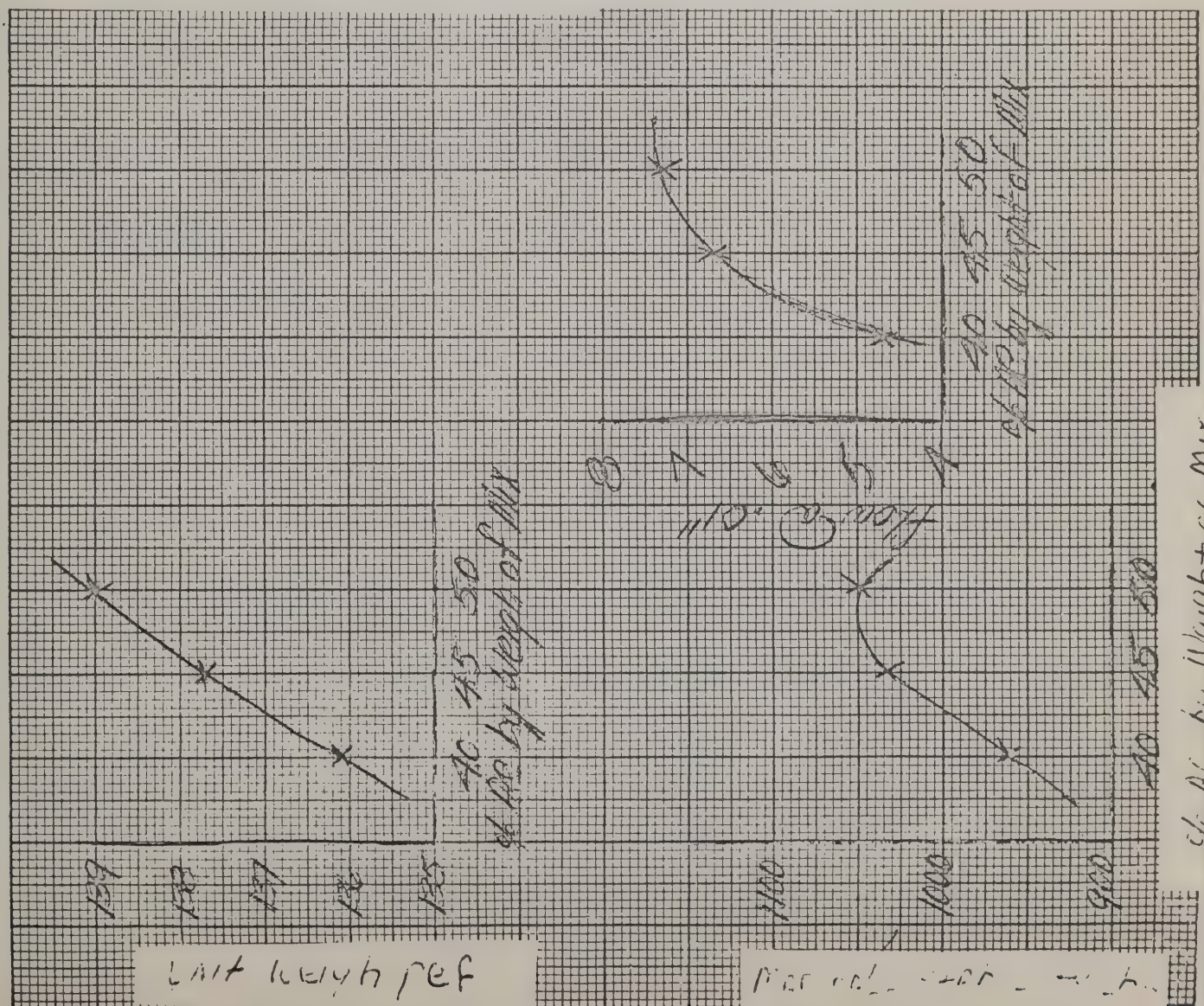
% AC-Spec No.	% AC-Spec No.	Spec. Hgt. IN.	Weight-Grams IN AIR	Weight-Grams IN WATER	Bulk Vol.-C.C.	Density Bulk	Density Max. Theor.	Volume-% Total AC	Volume-% Total Agg.	Volume-% Total Voids	Voids-% Agg	Voids-% Filled (Agg)	Voids-% Total Mix	Unit Wgt P.C.F.	Stability-lbs Meas.	Stability-lbs Adjust.	Flow 1/100"
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
% AC By wgt of Agg	% AC By wgt of Mix				D-E	D/F	*	B×G/G AC	(100-B)×G/G Ag	100-I-J	100-J	I/L	100-(100G/H)	62.4×G		**	
	4.0		1203	657	552	2.183								136.2	1037	924	6
	4.0		1139	618	521	2.182								136.1	1000	1000	4
	4.0		1165	631	534	2.178								135.9	100	960	4
	Avg					2.181	2.451	8.5	80.3	11.2	19.7	43.1	11.2	136.1		961	4.7
	4.5		1169	639	530	2.202								137.4	960	921	6
	4.5		1216	667	549	2.213								138.0	1237	1100	7
	4.5		1259	689	570	2.205								137.7	1250	1075	7
	Avg					2.206	2.439	9.7	80.7	9.6	19.3	50.3	9.6	137.7		1032	6.7
	5.0		1218	669	549	2.218								138.4	1325	1180	8
	5.0		1185	655	530	2.235								139.5	1020	980	7
	5.0		1114	614	506	2.230								139.2	950	990	7
	Avg					2.228	2.422	10.8	81.1	8.1	18.9	57.1	8.1	139.0		1050	7.3

* Max. Theor. Density

** See Correlation Table

$$\frac{100}{\frac{\%\ AC}{G\ AC} + \frac{\%\ Agg}{G\ Ag} + \frac{\%\ filler}{G\ filler}} = \text{Max. Theor Density}$$


% Voids Total Mix
% Voids Filled by Aggregate


Unit Weight pcf
Flow 8 to 16

FORM 16

JERSEY TESTING LABORATORIES INC.

ENGINEERS, LABORATORY AND INSPECTION SERVICE S-c559
154-156 WRIGHT STREET At McCarter Highway NEWARK, N. J.

ATCO, N. J. OFFICE
ROUTE #30, WHITEHORSE PIKE

10-7-63

1st Report of Asphaltic Concrete Mixture Design Order No. B-1196

Contract No.

CLIENT: Township of Woodbridge, N.J.
PROJECT: Various Streets (Woodbridge)
SUBJECT: Asphalt Concrete Mixture Design (Stabilize Base)
REPORTED TO: Mr. Charles Beagle, Twsp. Engineer

We have visited the Middlesex Concrete Products Asphalt Plant and secured the following materials.

Materials	Source
Asphalt Cement 60/70	Cities Service
Bank Run & Gravel	Middlesex Conc. Prod.

Analysis of these materials was made, and the following results were obtained.

Material

Total % Passing

1½"	Sieve	100
3/4"	"	95.7
3/8"	"	77.2
4	"	64.7
10	"	53.6
40	"	13.4
80	"	6.7
200	"	3.1

These materials were blended in the following proportions to produce the proper mixture.

Material	% Total Mix	5000# Batch
Asphalt Cement	6.1%	305#
Bank Run Sand	54.0%	2700#
1/4 Gravel	11.9%	595%
3/8 Gravel	13.0%	650#
3/4 Gravel	15.0%	750#
Totals	100.0%	5000#

FORM 16

JERSEY TESTING LABORATORIES INC.

S-6559

ENGINEERS, LABORATORY AND INSPECTION SERVICE
154-156 WRIGHT STREET At McCarter Highway NEWARK, N. J.

ATCO, N. J. OFFICE
ROUTE #30, WHITEHORSE PIKE

10-7-63

.....1st.....Report of Asphaltic Concrete Mixture Design Order No. B-1196

Contract No.....

CLIENT: Township of Woodbridge, N.J.
PROJECT: Various Streets (Woodbridge)

Analysis of these mixtures produced the following results.

Material		Spec.	Spec.		Spec.
Total % Passing					
1½"	Sieve	100	100	Asphalt Cement	6.1
3/4"	"	95.7	65-100	Stability	1720#
3/8"	"	78.4	50-90	Flow @ .0"	9.7
4	"	64.7	35-75	Voids %	3.5
10	"	53.6	25-60	Unit Weight p.c.f.	133.00#
40	"	13.4	12-30	% Agg. Voids Filled	61.0%
80	"	6.7	6-20		
200	"	3.1	3-8		
Asphalt Cement		6.1	4-7		

Remarks: Providing that adjustments for variations of materials are made, these mixtures should satisfy the project requirements pending approval of the engineer.

Respectfully submitted,

JERSEY TESTING LABORATORIES INC.

BY B. Winchester

Tech: D.L./mg

Trial Mix Series: Stabilized Base Bulk Run & Design Mix

Project: Various Streets
Location: Woodbridge
Date: 10-7-63

Sp. Gr. AC: 1.012 Pen. Grade AC 60/70 Lab No. for AC used
Avg. Sp. Gr. Agg. Blend 2.522 Lab No. for Agg. used

% AC-Spec No.	% AC-Spec No.	Spec. Hgt. IN.	Weight-Grams IN Air	Weight-Grams IN Water	Bulk Vol.-C.C.	Density Bulk	Density Max. Theor.	Volume-% Total AC	Volume-% Total Agg.	Volume-% Total Voids	Voids-% Agg	Voids-% Filled (Agg)	Voids-% Total Mix	Unit Wgt P.C.F.	Stability-Lbs Meas.	Stability-Lbs Adjust	Flow 1/100"
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
% AC By wgt of Agg	% AC By wgt of Mix				D-E	D/F	*	B×G / G AC	(100-B)×G / G Ag	100-I-J	100-J	I/L	100(100G/H)	62.4×G		**	
4.17	4.0		1018	520	498	2.041									805	838	7
4.17	4.0		977	495	482	2.025									915	1042	6
4.17	4.0		1027	527	500	2.052									735	765	7
	Avg					2.039	2.402	8.1	77.6	14.3	22.4	36.8	15.2	127.23		821	6.7
5.26	5.0		1031	532	499	2.063									1020	1060	9
5.26	5.0		1025	530	495	2.071									865	941	8
5.26	5.0		931	507	474	2.073									890	970	9
	Avg					2.069	2367	10.2	77.9	11.9	21.1	49.3	12.6	129.11		990	8.7
6.39	6.0		984	528	456	2.158									1050	1310	10
6.39	6.0		1023	540	483	2.117									915	998	9
6.39	6.0		1191	633	564	2.121									1300	1118	10
	Avg.					2.132	2336	12.6	79.5	7.9	20.5	61.5	8.3	133.03		1147	9.7

* Max. Theor. Density
** See Correlation Table

$$\frac{100}{\frac{\%\ AC}{G\ AC} + \frac{\%\ Agg}{G\ Ag} + \frac{\%\ filler}{G\ filler}} = \text{Max. Theor Density}$$

Trial Mix Series: Stabilized Base
Base Rock Gravel Mix

Project: Various Streets
Location: Woodbridge
Date: 10-7-63

Sp. Gr. AC: 1.012 Pen. Grade AC 60/70 Lab No. for AC used
Avg. Sp. Gr. Agg. Blend 2.522 Lab No. for Agg. used

% AC-Spec No.	% AC-Spec No.	Spec. Hgt. IN.	Weight-Grams IN Air	Weight-Grams IN Water	Bulk Vol.-C.C.	Density Bulk	Density Max. Theor.	Volume-% Total AC	Volume-% Total Agg.	Volume-% Total Voids	Voids-% Agg	Voids-% Filled (Agg)	Voids-% Total Mix	Unit Wgt P.C.F.	Stability-Lbs Meas.	Stability-Lbs Adjust.	Flow 1/100"
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
% AC By wgt of Agg	% AC By wgt of Mix				D-E	D/F	*	B×G/G AC	(100-B)×G/G Ag	100-I-J	100-J	I/L	100(1-G/H)	62.4×G		**	
7.61	7.0		1075	572	503	2.137									765	910	9
7.61	7.0		1101	584	517	2.130									935	973	9
7.61	7.0		986	463	463	2.128									952	952	9
						2.131	2.304	14.7	78.6	6.7	21.4	18.7	7.5	132.97		945	9

* Max. Theor. Density
** See Correlation Table

$$\text{Max. Theor Density} = \frac{100}{\frac{\%\ \text{AC}}{G\ \text{AC}} + \frac{\%\ \text{Agg}}{G\ \text{Ag}} + \frac{\%\ \text{filler}}{G\ \text{filler}}}$$

JERSEY TESTING LABORATORIES INC.
Engineers, Laboratory and Inspection Service
154-156 WRIGHT ST. AT McCARTER HIGHWAY NEWARK 2, N. J.
BIGELOW 8-6000-1-2-3

Sheet 5 of 5